РЕГИОНАЛЬНАЯ И ОТРАСЛЕВАЯ ЭКОНОМИКА

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The impact of supply chain disruptions caused by international sanctions on the development of sovereign economies: Difference-in-Difference methods of analysis

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Abstract. International sanction highly disrupts the food supply chains by increasing production and transportation costs, reducing trade flows, and affecting macroeconomic performance. Therefore, this study is relevant in addressing the impacts of supply chain disruption caused by international sanctions on the development of sovereign economies to enhance the efficiency of food supply.

Aim. The study is to investigate the impact of supply chain disruption caused by international sanctions on the development of sovereign economies.

Materials and methods. The data were collected from the World Bank database and compiled in the panel dataset. For this purpose, the study employed both descriptive and inferential statistics to analyze the panel dataset.

Result. The findings reveal that international sanctions significantly affect Russia's trade balance, oil rents, foreign direct investment and real effective exchange rate inflows relative to China and Brazil.

Conclusion. This study provides empirical evidence on the supply chain channels through which international sanctions impact sovereign economic development. The results offer insights for policymakers and stakeholders in designing strategies to mitigate supply chain disruptions and enhance economic resilience under sanctions.

Keywords: Supply chain disruption, International sanction, GDP growth, Oil rents, Sovereign economy, trade balance, difference in difference

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УДК 658.7 Научная статья

Влияние сбоев в цепочках поставок, вызванных международными санкциями, на развитие суверенных экономик: метод «Difference-in-Differences»

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Аннотация. Международные санкции существенно нарушают цепочки поставок продовольствия, увеличивая производственные и транспортные издержки, сокращая торговые потоки и влияя на макроэкономические показатели. Данное исследование актуально для изучения влияния сбоев в цепочках поставок, вызванных международными санкциями, на развитие суверенных экономик и организацию поставок продовольствия.

Цель исследования – изучение влияния сбоев в цепочках поставок, вызванных международными санкциями, на развитие суверенных экономик.

Материалы и методы. Информация была собрана из базы данных Всемирного банка и объединена в панельный набор данных. В исследовании использовались как описательная, так и инференциальная статистика для анализа панельного набора данных.

Результаты исследования показывают, что международные санкции существенно влияют на торговые связи России и нефтяную ренту, прямые иностранные инвестиции и реальный эффективный валютный курс по сравнению с Китаем и Бразилией.

Заключение. Данное исследование предоставляет эмпирические данные о направлениях влияния сбоев в цепочках поставок, вызванных международными санкциями, на развитие суверенной экономики. Результаты дают представление заинтересованным сторонам о стратегиях смягчения сбоев цепочек поставок и повышения экономической устойчивости в условиях санкций.

Ключевые слова: сбои в цепочке поставок, международные санкции, рост ВВП, нефтяная рента, суверенная экономика, торговый баланс, метод «Разность разностей»

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INTRODUCTION

International obligation refers to the duties that states are bound to endorse under international law, such as the obligation not to cause significant harm to other states, particularly in the context of transboundary water resources and environmental protection [1, 2]. Since World War I, international organizations and nations have often applied sanctions as a routine policy tool to react to any nation's actions they oppose. Sanctions had a different success rate, depending on the costs imposed on the targeted nation, their reaction to these costs, and the influence on the economy and public opinion in other countries [3]. International institutions

play an important role in establishing global standards and fostering cooperation, smoother logistics, and trade flows [4]. Multinational corporations (MNCs) benefit from these frameworks, as they increase the efficiency and productivity of suppliers [5]. Air transport and logistics improvements can significantly boost economic growth and stability [6]. International sanctions against Russia have led to the closure of EU airspace and ports for Russian companies, severely disrupting logistics networks and increasing travel times and costs for transport companies. Transport operators have faced restrictions that have forced them to seek alternative routes, complicating logistics operations and supply chains [7]. Traffic along alternative logistics corridors with Turkey has increased, which has become a vital route for freight transport due to the disruptions in traditional paths and increased cargo volumes in this corridor [8]. Russian logistics faces challenges due to sanctions and trade blockades, but it maintains flexibility and sustainability, proving highly adaptable to changes in the business environment and operating conditions [9]. Economic sanctions have led to inflation, and reduced access to healthcare and medicines, particularly affecting vulnerable populations [10]. These disruptions directly impact Russia's ability to participate effectively in global supply chains. In the petroleum industry, sanctions limited access to foreign direct investments and crucial technologies from the EU and the US, affecting major Russian companies [11]. However, the sanctions have also created opportunities for import substitution and technological sovereignty. Despite the challenges, Russia has shown resilience in adapting to the new economic reality, with the potential for sustainable development through intensified import substitution policies [12]. The impact of sanctions on Russia's economy and exchange rate has been significant [13]. In this study, supply chain disruptions are defined as interruptions in the flow of goods, services, and capital, including reduced trade flows, increased costs of intermediate inputs, and limitations on foreign investment, which collectively affect production and distribution networks. Key macroeconomic indicators such as trade balance, foreign direct investment inflows, real effective exchange rate, inflation rate, oil rents, and GDP growth serve as proxies to measure the channels through which sanctions disrupt supply chains and affect Russia's economic development. Although prior studies have examined the macroeconomic consequences of sanctions, there is limited empirical evidence quantifying the impact of sanctions specifically on supply chain disruptions in Russia's sovereign economy. This study closes this gap in scientific knowledge. Generally, this study answers the following specific research questions;

- What are the macroeconomic trends in Russia's sovereign economy compared to Brazil and China before and after the imposition of sanctions?
- Which indicator is significantly disrupting the supply chain as a result of international sanctions imposed on Russia's sovereign economy?

This study is practically important to stakeholders in developing strategies to reduce the impacts of supply chain disruption caused by international sanctions and achieve high economic growth and a stable economy. The remainder of this research article is organized into 4 sections. Section 2, materials and methods, offers a straightforward overview of the methods employed. In Section 3, the results and discussion are presented with their implications. Finally, Section 4 presents the conclusion and recommendations.

1. MATERIALS AND METHODS

This study employs panel data from 2014 to 2023. The data was collected from the World Bank databases for Russia, China, and Brazil. These countries were selected based on a combination of economic relevance, geographical contexts, and founding members of BRICS. The collected data were arranged into a comprehensive panel dataset that encompasses variables relating to GDP growth, inflation rate, foreign direct investment net inflow, real effective exchange rate, trade balance, and oil rents. However, not all the data were available in the database for each variable; thus, the study interpolated the missing variables and estimated the results.

1.1. METHOD OF ANALYSIS

This study employed both descriptive and inferential statistics. Descriptive statistics were used to illustrate the trends in GDP growth, inflation, foreign direct investment, unemployment, real effective exchange rate, oil revenue, and trade balance, before and after the implementation of international sanctions against Russia, in comparison with Brazil and China. Inferential statistics include the t-test (mean comparison) and Difference-in-Differences (DiD) estimation methods used to examine the impact of supply chain disruptions caused by international sanctions on GDP growth in the context of the Russian development of sovereign economies.

1.2. MODEL SPECIFICATION

This study examines international economic sanctions against Russia's sovereign economy. Difference in differences compares the changes in outcomes over time between units enrolled in an experiment (the treatment group) and units not enrolled (the control group). This allows us to correct any differences between the control groups and treatment that are constant over time [14]. The period from 2014 to 2021 represents integrated supply chains, whereas the period from 2022 is classified as a period with post-sanctions or disrupted supply chains. Two categories are defined: those directly affected by the imposition of the sanction (Russia) and those not directly affected by the sanction (Brazil and China). Based on these categories, which take a value of 1, if the treated group (Russia) and the value of 0, the control group (Brazil and China) has no international sanctions. This study used the DiD estimation model, which models the GDP growth as a function of the inflation rate, foreign direct investment, real effective exchange rate, oil rents, and trade balance as variables to examine the impacts of supply chain disruption caused by international sanctions on the development of Russia's sovereign economy. The basic (DiD) estimation model with panel data is expressed as follows:

$$GDP_{it} = \alpha_i + \lambda_t + \chi_{it}^{`}\gamma + \delta DiD_{it} + \varepsilon_{it}.$$

Where, GDP_{it}: Gross domestic product annual growth rate (i) country and (t) time

$X`_{it}\gamma$: vector of control variables (trade % of GDP), FDI net inflow (% of GDP), oil rents (% of GDP); inflation rate consumer price index (annual %), and real effective exchange rate.

αi: Country-fixed effects

λt: year fixed effect

1.3. Description and measurement of variables

Table 1. Variable descriptions and measurements

Variables	Description of the variables	Linkage with supply chains	Measurements
GDP growth	A proxy variable for the development of a sovereign economy, which is calculated annually.	A country's supply chain efficiency significantly affects GDP growth. Strong economies with well-functioning supply chains boost productivity, reduce costs, and improve customer satisfaction, while weak supply chains lead to higher costs, delays, and disruptions that hinder economic growth.	%
Trade balance	It is the difference between exports and imports of goods and services, expressed as a share of gross domestic product.	Trade balance %GDP reflects a country's net trade position and external dependence, while supply chain disruptions such as economic sanctions raise import costs and domestic prices, thereby worsening trade deficits and undermine food supply chain stability.	% of GDP
DiD	An interaction variable (treated*time)	It reflects the impacts of sanctions on the supply chain over time.	time effect
Foreign direct investment, net inflows(FDI)	It refers the net inflows of investment to acquire a lasting management interest in an enterprise operating in an economy other than that of the investor.	FDI inflow offers firms the opportunity to secure inputs, access markets, cut costs, diversify, and adopt new technologies, reshaping global production networks and strengthening local capabilities.	% of GDP
Oil rent	Oil rent is the income received from the sale of oil minus the costs of its production and transportation.	Oil is tightly embedded in global supply chains as a core transport fuel and industrial input. Higher oil prices raise shipping and manufacturing costs, fueling inflation.	% of GDP
Inflation rate	Annual percentages of average consumer prices are year-on-year changes.	High inflation rate can disrupt the supply chain, increase the cost of transport increasing production costs, and raise operating expenses.	%
Real effective exchange rate (REER)	The nominal effective exchange rate is divided by a price deflator or index of costs.	It affects supply chains by influencing costs, competitiveness, and stability. A weaker REER can increase volatility and strain firms' profit margins and liquidity, especially when imported inputs are widely used.	This indicator is an index series where 2010=100.

2. Result and Discussion

This study describes and interprets the findings obtained from secondary sources of data. The result of the study focuses on the impact of supply chain disruption caused by international sanctions on the development of sovereign economies in the context of Russia, compared with China and Brazil.

2.1. Descriptive statistics

2.1.1. Trend analysis before and after international sanctions on the development of Sovereign Economies

Figure 1 depicts the GDP growth trends for Brazil, China, and Russia. The GDP growth of China shows a relatively flat trend with minimal fluctuations until 2019, a decline onwards in 2020, and again reaching a peak point in 2021. Lastly, between 2021 and 2023, shows a high fluctuation. Russia's GDP growth showed some volatility from 2014 to 2019, peaking in 2021. Russia's GDP growth rate declined in 2022 following the imposition of sanctions. The decline in Russia's GDP growth was due to the imposition of sanctions and potential disruptions to trade,

investment, and supply chain operations. By 2023, the Russian economy began to recover, although its performance was lower than China's and higher than Brazil's. Brazil's GDP growth exhibited periods of contraction and recovery between 2014 and 2023.

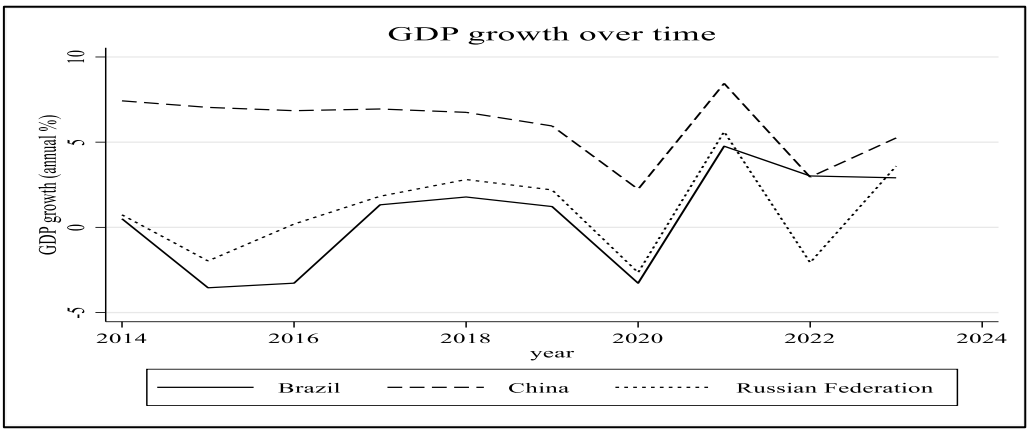

Fig. 1. *GDP growth trend of Brazil, China, and Russia from 2014 to 2023[15]*

The trade balance for Brazil, China, and Russia is presented in Figure 2. Russia's trade integration was greater than China's and Brazil's, but it fluctuated greatly from 2014 to 2020, reaching a high point in 2022 and then rapidly declining during the disrupted supply chain following the introduction of international sanctions. This implies sanctions, and disruption in trade routes affects trade balance as well as the development of the Russian sovereign economy. This study is consistent with [16]. China's trade balance has experienced stable fluctuation from 2014 to 2023, with little growth over time, but has remained continuously low when compared to Russia. From 2014 to 2023, Brazil's trade balance displayed a trend of high fluctuation.

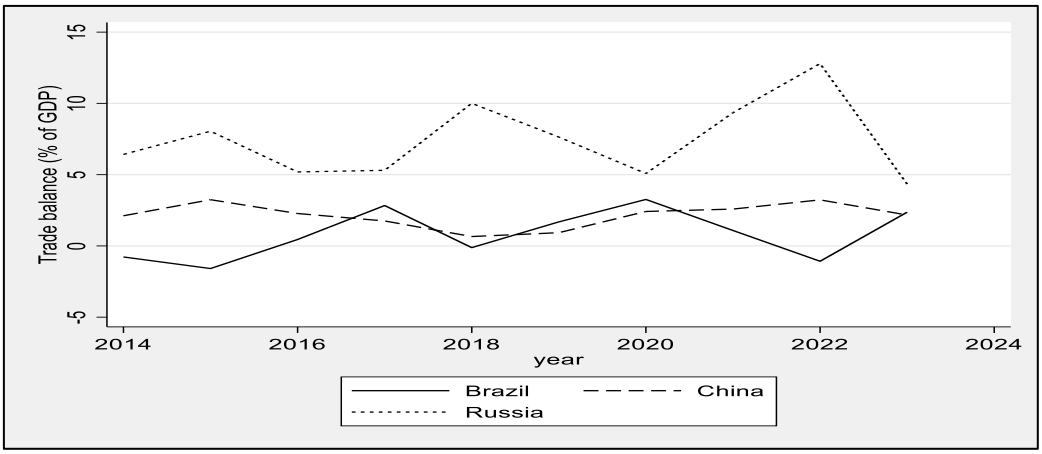

Fig. 2. *Trade balance as a percentage of GDP for Brazil, China, and Russia [15]*

Russia, China, and Brazil's oil rents are presented in Figure 3. The contribution of oil rents to GDP lays between 4.3% and 10% Russia's revenue from 2014 to 2023, reaching the peak points in 2018 and 2021. The international sanctions created a growing global energy uncertainty. Oil rents were the critical components of the Russian economy, and a net oil exporter, but the trends sharply declined during disrupted supply chain. Therefore, analysis of the dynamics of oil revenues is essential for understanding the conditions of Russia's macroeconomic vulnerability and resilience during disrupted supply chain. Brazil's oil rents

show fluctuation between 2014 and 2020, with slightly increasing trends after 2020. Meanwhile, China constantly showed minimal oil rents from 2014 to 2023 as a net oil importer. This study is consistent with [17].

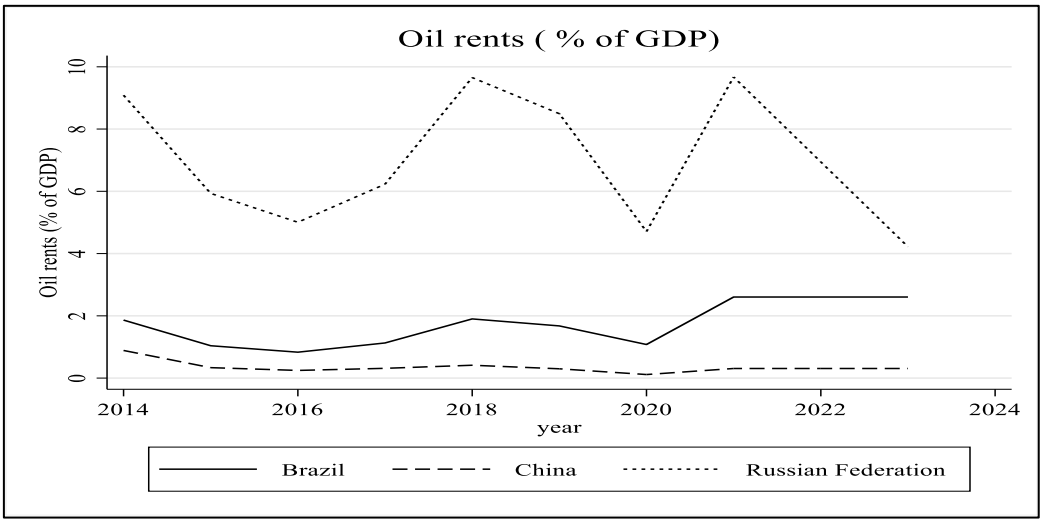

***Fig. 3**. Oil rent trends for Brazil, China, and Russia (2014-2023) [15]*

Figure 4 presents the foreign direct investment (FDI) net inflow trends for three countries from 2014 to 2023. Russia's FDI net inflows trend shows between 0.5% to 2.5% share of GDP growth, but after 2021 to 2022, a sharp decline and below zero. After 2022, a slowdown in the rate of decline in FDI is observed, but the value is still negative. This study is in line with [11]. China's FDI net inflows exhibit a more fluctuating trend between 2014 and 2021. However, it has been declining sharply since 2022. Net FDI inflows to Brazil are higher than to Russia and China, and are characterized by minor ups and downs.

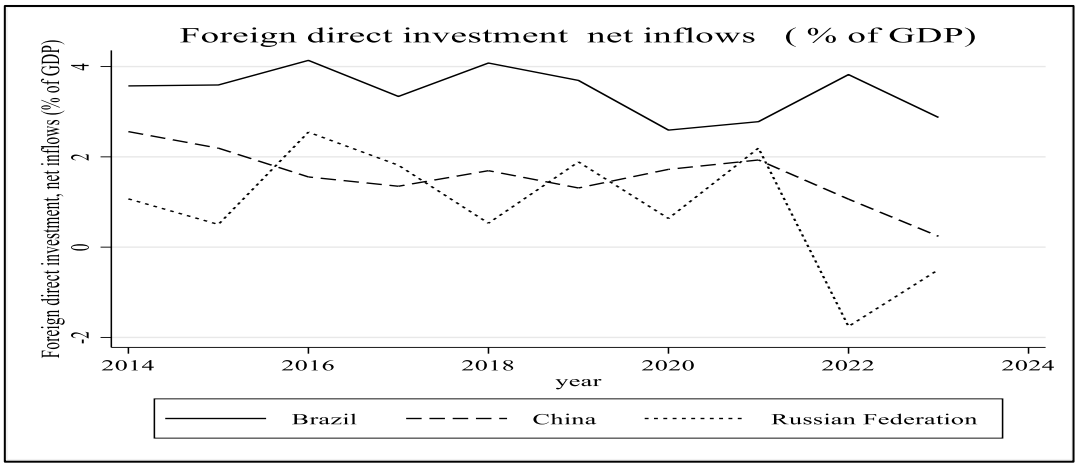

***Fig. 4**. Foreign direct investment net inflow trends of Brazil, China, and Russia (2014–2023) [15]*

The trends of the inflation rate for Brazil, China, and Russia are depicted in Figure 5. The inflation rate in Russia was between 2.8% and 15.5% from 2014 to 2023. However, after international sanctions inflation rate slightly decreased. The trends of the inflation rate in Brazil lie between 3% to 9% from 2014 and 2023. China's inflation rate shows a slight variation between 4% and 5% from 2014 to 2023, which is less than Russia and Brazil. The inflation rates in China, Brazil, and Russia reduced from 2022 to 2023.

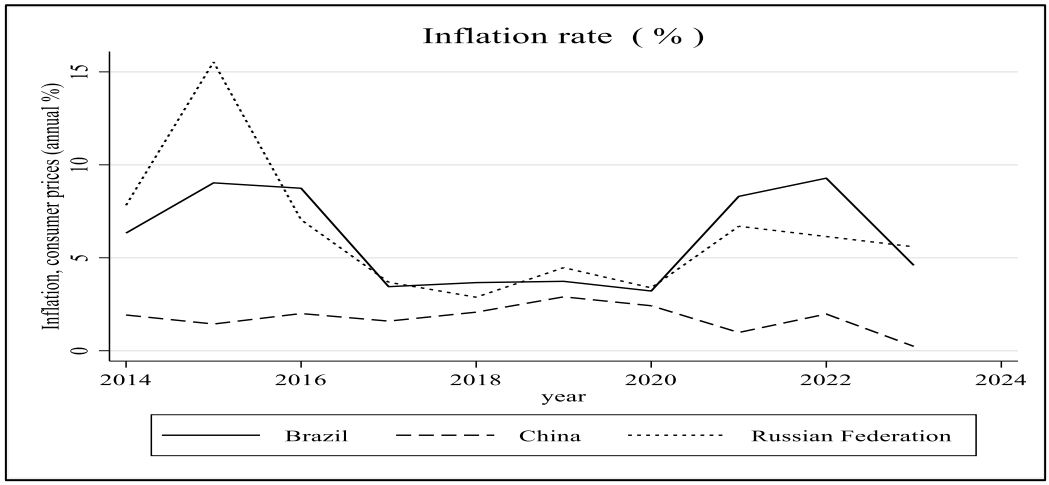

***Fig. 5**. Inflation rate of China, Brazil, and Russia (2014-2023) [15]*

Figure 6 depicts the real effective exchange rates for three countries between 2014 and 2023. China's real effective exchange rate trend lies between 116 and 130 from 2014 to 2023, which means an increase of 16% to 30% more expensive in real terms as compared to the base year. Brazil's real effective exchange rate is between 53 and 84 from 2014 to 2023, which means the Brazilian Real from 47% to 16% weaker in real purchasing power as compared to the base year. Russia's real effective exchange rate ranges between 80 and 100. It means Russian Rubles are 20% weaker and equal to the base year. This study is in line with [18].

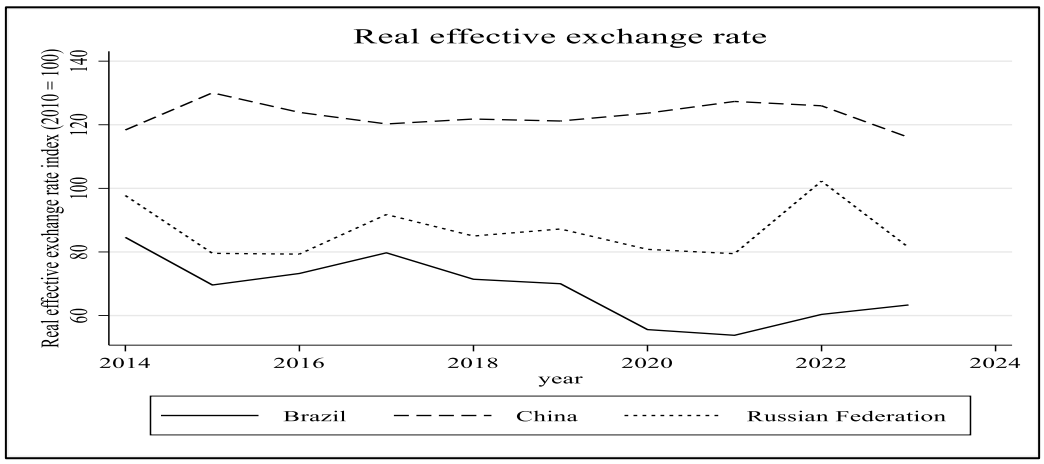

***Fig. 6**.The real effective exchange rate of Brazil, China, and Russia (2014-2023) [15]*

2.2. Inferential statistics

2.2.1. Parallel Trends Assumption

The null hypothesis should be accepted if the p-value is greater than 0.05, indicating that linear trends are parallel. The parallel trend assumption states that the difference between the treatment and control groups remains constant over time in the absence of treatment. Failure to follow this assumption will result in biased causal effect estimation[14]. Based on the stated parallel trend assumption, the p-value is 0.7927, which is greater than 0.05, implying acceptance of the null hypothesis. As a result, the treated and control groups continue to follow parallel pathways. Figure 7 and Table 2 illustrate a parallel trend.

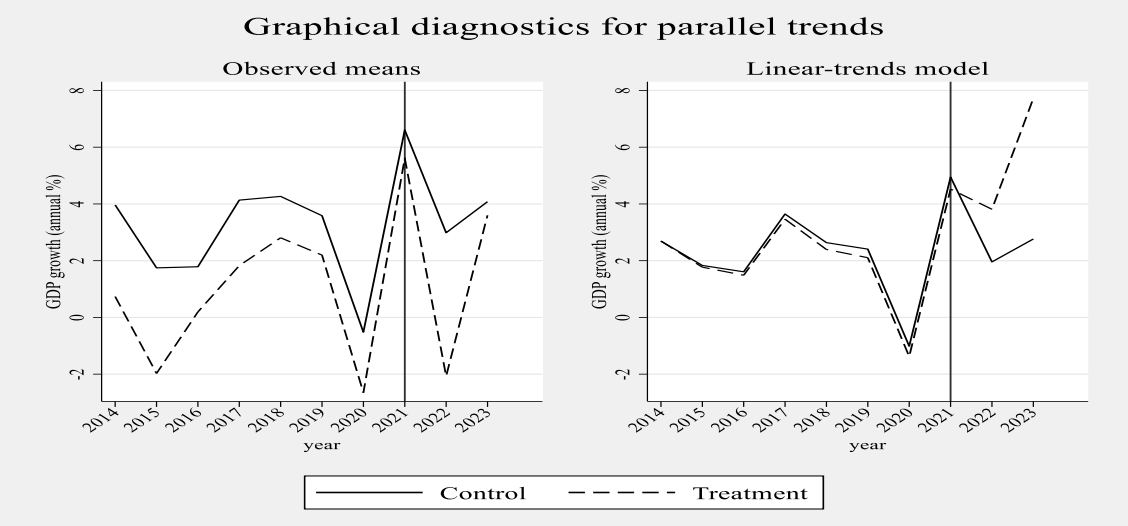

***Fig. 7**. Graphical representation of parallel trend*

Table 2. Parallel-trends test (pretreatment period)

H0: Linear trends are parallel	
F(1, 2)	0.09
Prob > F	0.7927

2.2.2. IMPACTS OF SUPPLY CHAIN DISRUPTIONS CAUSED BY INTERNATIONAL SANCTIONS ON THE DEVELOPMENT OF SOVEREIGN ECONOMIES

Table 3 shows Brazil, China, and Russia's dynamics of macroeconomic indicators. It depicts that Russia's GDP growth has shown a substantial decline during disrupted supply chains. However, the t-test results show that there wasn't a significant difference in GDP growth during integrated supply and disrupted supply chains between the control group (Brazil and China) and the treated group (Russia). The mean trade balance for the control group's integrated food supply chain is 1.43%, and 7.12% for the treated group, and 1.67% and 8.57% for the control and treated groups' disrupted supply chains. The t-test results show there was a significant difference in the trade balance between the control and treated groups during integrated supply chain and disrupted supply chains at a 1% level of significance. This indicates Russia maintains a higher trade balance than China and Brazil, but the international sanctions have decreased imports of goods and services. This study aligns with [19].

The mean of foreign direct investment net inflows during the integrated supply chain was 2.63% and 1.40% for the control and treated groups, and 2.00% and -1.13% for the control and treated groups' disrupted supply chains. A significant decrease in foreign direct investment net inflows for Russia under disrupted supply chains implies a loss of foreign investors' confidence and economic isolation, contrasting with China's and Brazil's stable foreign direct investment net inflow levels. This finding is consistent with [20].

The mean oil rents during the integrated supply chain for the control and treated groups are 0.94% and 7.35%, and for disrupted supply chains, 1.46% and 5.58% for the control and treated groups, respectively. The t-test results show there was a significant difference in oil rent between control and treated groups during integrated supply chain and disrupted supply chains

at a 10% level of significance. Russia had high oil rent but it declined after disrupted supply chains, which implies that sanctions affect the oil sector's profitability and the overall performance of the economy.

Table 3. Pre and post-sanction comparative analysis of the key variables

Variable	Integrated supply chain			Post-sanction/disrupted supply chains			DiD P>|t|
	Control	Treated	(T-C) *p*-value)	Control	Treated	(T-C) *p*-value)	
GDP growth (annual %)	3.20 (1.04)	1.10 (0.940)	0.18	3.53 (0.573)	0.765 (2.83)	0.376	0.85
Trade balance (% of GDP)	1.43 (0.36)	7.13 (0.68)	0.00***	1.67 (0.95)	8.57 (4.23)	0.000***	0.54
Foreign direct investment, net inflows (% of GDP)	2.63 (0.25)	1.40 (0.29)	0.011**	2.00 0(.82)	-1.13 (0.63)	0.002***	0.07*
Oil rents (% of GDP)	0.94 (0.18)	7.35 (0.74)	0.00***	1.46 (0.66)	5.58 (1.36)	0.002***	0.095*
Inflation, consumer prices (annual %)	3.86 (0.68)	6.44 (1.46)	0.079*	4.02 (1.97)	5.87 (0.28)	0.518	0.818
Real effective exchange rate	96.53 (7.18)	85.12 (2.40)	0.304	91.43 (17.21)	91.85 (10.42)	0.985	0.631

**Inference: *** p<0.01; ** p<0.05; * p<0.1
Note. The standard deviation is in the parentheses.
Source: Authors preparation based on Stata 17

The mean inflation rate during the integrated supply chain for the control and treated groups is 3.86% and 6.44%, and after the sanctions, it is 4.02 % and 5.87 % for the control and treated groups. This result indicates that Russia had a lower real effective exchange rate than the control group of countries before the imposition of sanctions, giving it higher price competitiveness compared to China and Brazil during this period. However, Russia's real effective exchange rate converged with those of China and Brazil in the post-sanctions period. A country with a higher real effective exchange rate has lower international competitiveness, as its goods and services become more expensive [21].

2.2.3. THE INDICTORS OF SUPPLY CHAIN DISRUPTION UNDER SANCTION

Table 4 shows the estimation result of the difference in difference estimation.

The DiD analysis revealed that international sanctions imposed on Russia have significant effects on both macroeconomic outcomes and key supply chain channels. The estimation result shows that the effect of sanction, trade balance (% of GDP) are significant at 1 %, oil rents at 5 %, foreign direct investment net inflows, and real effective exchange rate at 10 % level of significance.

The coefficient of DiD is positive and significant at 1% level of significance. The effect of sanctions has a positive impact on the growth of GDP growth during the period under review.

The Russian GDP growth increased by about 6.42 % more than the control group (Brazil and China), holding other things constant. These findings contrast with [10, 22]. However, Russia offsets the effect of sanctions through import substitution and shifts its trade partners, and increases revenues from commodity exports. This study is consistent with [12] and [23].

Table 4. Fixed effect DiD model estimation result (panel data)

Variables	Variable level	GDP growth	*p*-value
Difference in difference(DiD)	Effect of sanctions	6.417*** (0.597)	0.009
Trade balance	Trade balance (% of GDP)	-0.349*** (0.0109)	0.001
Oil rent	Oil rents (% of GDP)	1.443** (0.328)	0.048
IR	Inflation rate (%)	-0.221 (0.131)	0.233
FDI	Foreign direct investment net inflows	1.226* (0.361)	0.077
REER	Real effective exchange rate	-0.108* (0.0363)	0.096
Constant	Intercept	7.589 (3.135)	0.137
Observations	Total number of observations	30	–
Number of Id	Number country(Russia,Brzail and China)	3	–
R-squared		0.533	–

Robust standard errors in parentheses
***)p <0.01, **)p <0.05, *)p <0.1
Source: Author preparation based on Stata 17

The coefficient of trade balance is negative and significant at 1%. This indicates that the sanctions restricted import channels and caused logistical breakdown, limiting countries' abilities to import essential inputs and technologies. As a result, imports declined more than exports, artificially improving the trade balance, but hurting GDP growth because domestic production slowed due to the lack of input availability. Sanctions disrupted production and supply chains in the country. Trade surplus under the sanctions hides the real weakness of the economy, creates supply chain disruption, and results contracting domestic economy. This study is consistent with [23], in which sanction-induced trade distortions in Russia challenged production capacity and economic performance, despite the trade surplus. The coefficient of oil rents is positive and significant at a 5% level of significance. The positive sign indicates that even if a country is under sanction, oil rents play a crucial role in generating revenue and supporting the country's GDP growth. A 1% increase in oil rents, and then GDP growth increased by 1.44% more than the control group, while other things remain constant. The Russian economy heavily depends on exporting oil and gas. This study is in line with [24].

In summary, the indictors most closely with supply chain disruption under sanction are trade balance, real effective exchange rate, foreign direct investment inflows and oil rents. Trade and real effective exchange rate capture constraints in the flow and cost of production inputs, while oil rents and foreign direct investment inflows highlight sectoral resilience and targeted investment.

3. Conclusion and Recommendation

International sanctions significantly disrupt the socioeconomic indicators of sanctioned countries, particularly by affecting trade flows, investment, and key production networks. This study examined the impact of sanctions-induced supply chain disruptions on the development of sovereign economies, using Russia as the sanctioned country and China and

Brazil as control countries. World Bank panel data were analyzed using descriptive statistics, t-tests, and the difference-in-differences fixed effects estimator. The descriptive statistics show that the trade balance declined after the imposition of sanctions; however, net FDI inflows and GDP growth increased. The t-test indicates a significant difference in net FDI inflows, trade balance, and oil rents between the sanctioned countries (Russia) and the control groups (China and Brazil) after the imposition of sanctions. Results from a difference-in-differences fixed-effects approach showed that the trade balance and oil rents have a significant impact on supply chain disruptions caused by international sanctions. Based on these findings, several measures can be proposed to improve supply chain resilience and economic development in sanctioned countries. These include diversifying trading partners and logistics corridors, increasing exports and imports to stimulate domestic production, enhancing export competitiveness, participating in multilateral organizations to mitigate sanctions, and implementing innovative technologies. Efforts should be made to improve the efficiency and sustainability of revenues from the oil sector through infrastructure investment and diversification to ensure the availability of oil supplies to non-sanctioned countries.

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